# performance of isolated lepton finders

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ILD Analysis/Software Meeting, Oct. 21

idea to select a isolated lepton (e/μ)

i) lepton ID: electron or muon

- energy ratio deposited in ECal, HCal, Yoke
- general PID: dE/dx + shower profile

ii) vertex: prompt or secondary

- d0, z0 significance: d0/δd0, z0/δz0

iii) isolation: not from jets

- relatively high P
- almost empty around

status of available tools

i) lepton ID: electron or muon

- energy ratio deposited in ECal, HCal, Yoke ✔
- general PID: dE/dx + shower profile to be added

ii) vertex: prompt or secondary

- d0, z0 significance: d0/δd0, z0/δz0 ✔

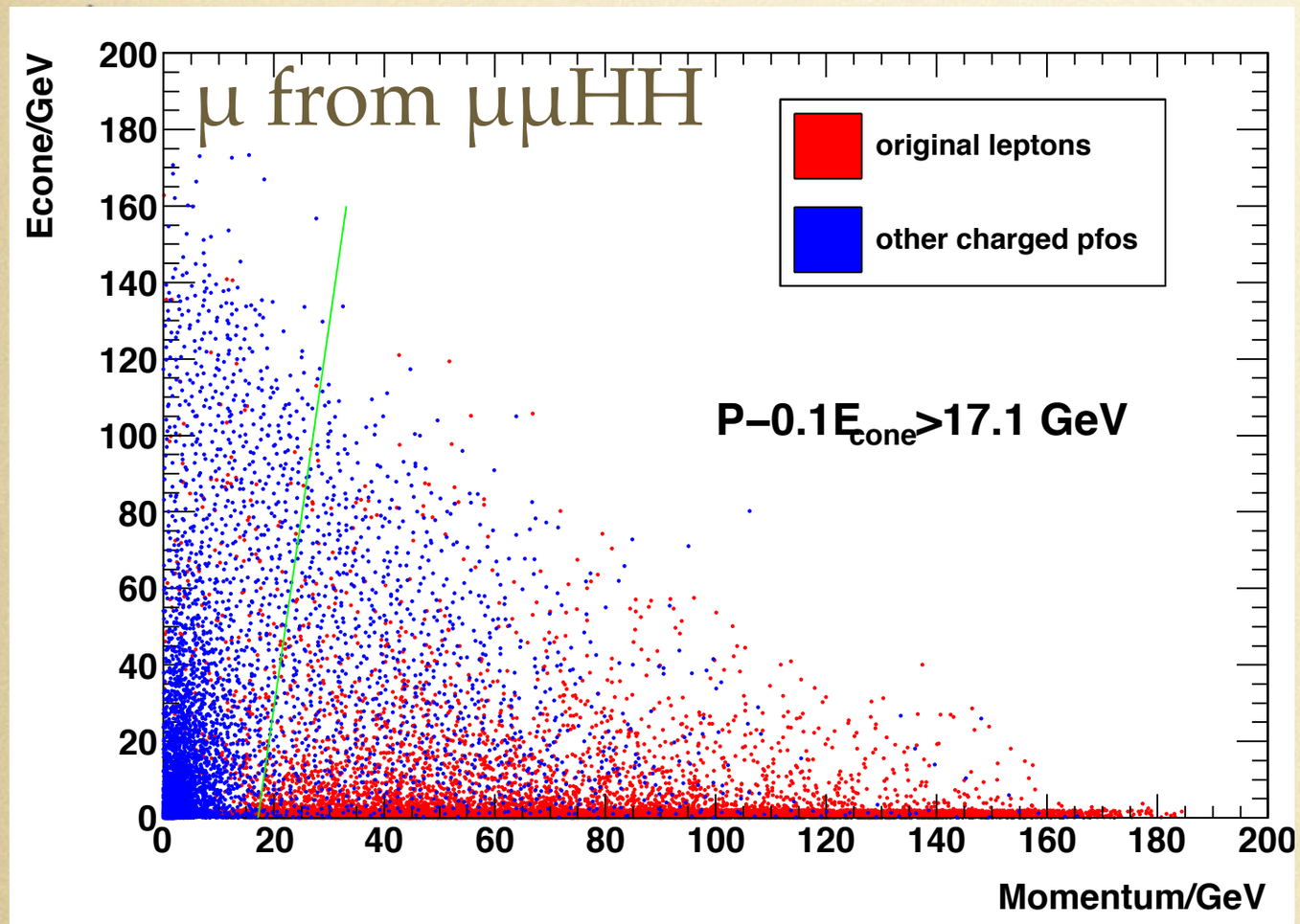
iii) isolation: not from jets ✔

- relatively high P
- almost empty around

several algorithms exist

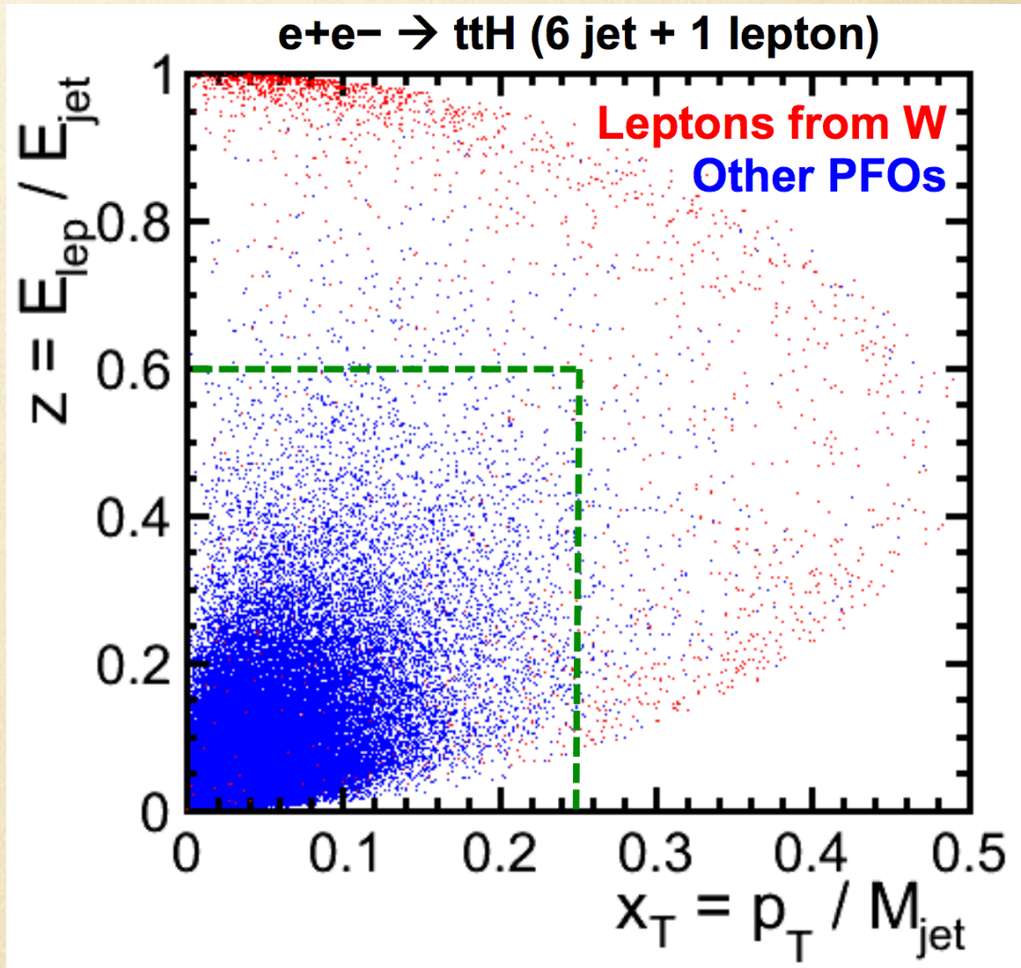
# two isolation algorithms in DBD

## cone based




(Ryo / Tomohiko; Junping)

## jet based




(M.Amjad / LAL group)

both available during DBD, in MarlinReco / Analysis / IsolatedLeptonFinder

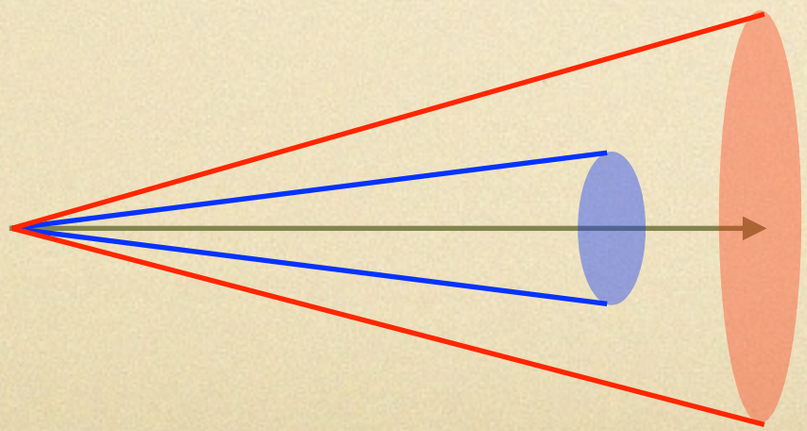
# New idea for further improvement:

(developed by Claude/Junping for Higgs self-coupling analysis)

- utilise d0, z0, cone energy, momentum, Eecal/Ehcal more effectively —> MVA

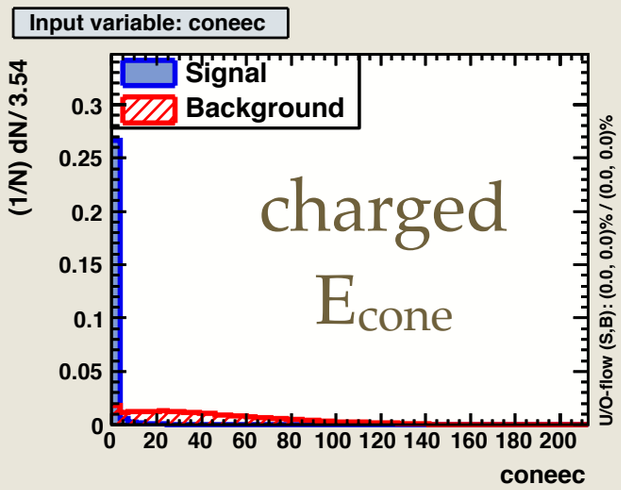
- rethink of "what is isolation?" in terms of separation with "non-isolated" ones from jets —> utilise information of neighbour particles in every layer of cone

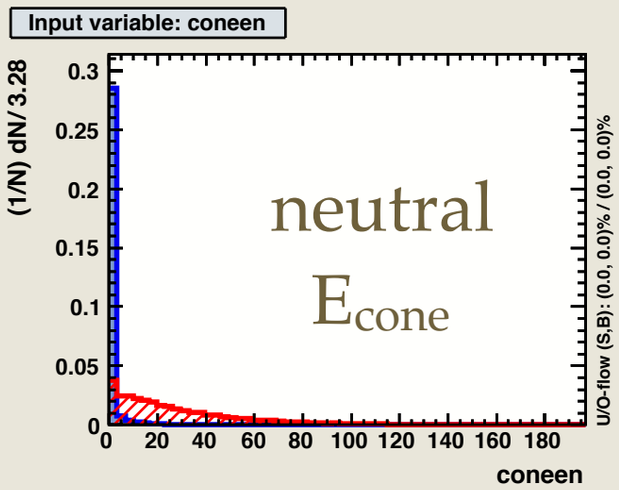
- as a first trial, introduce double cones to magnify the jet influence —> E(lep)/E(jet) and angle between them

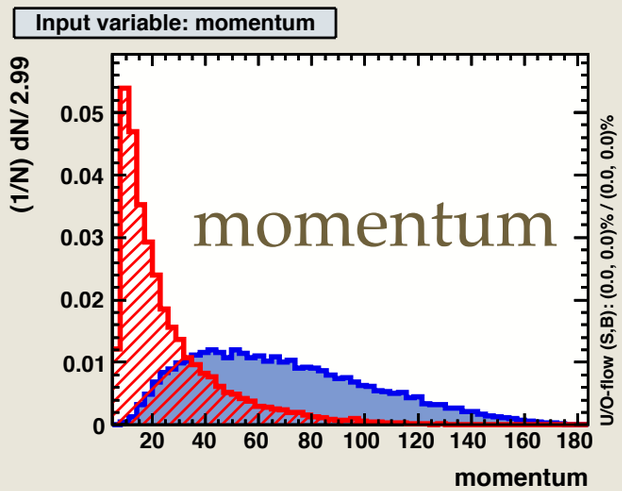


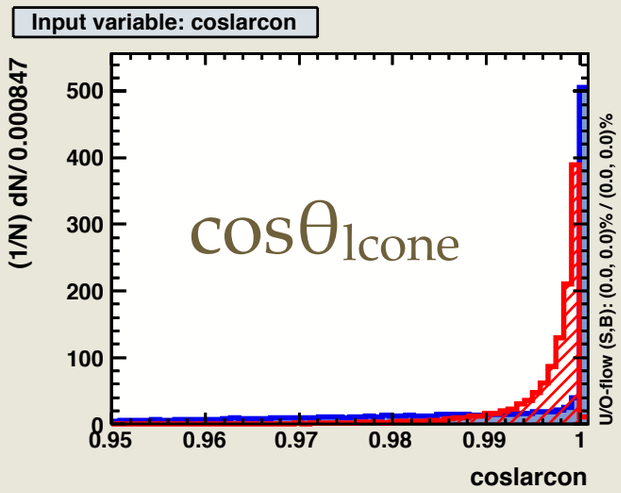
cos=0.98, 95

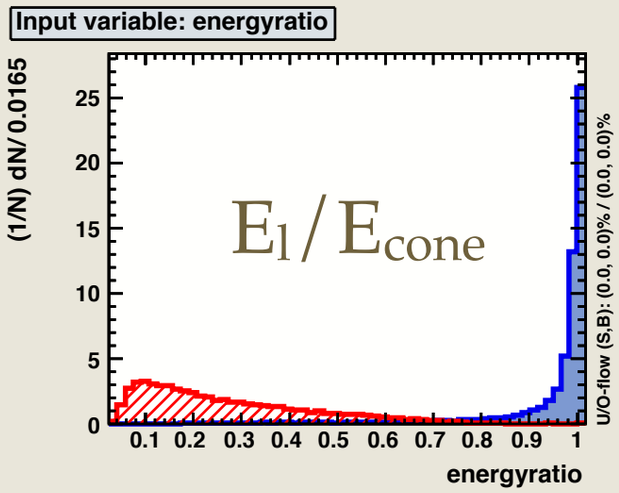
# input variables: muon

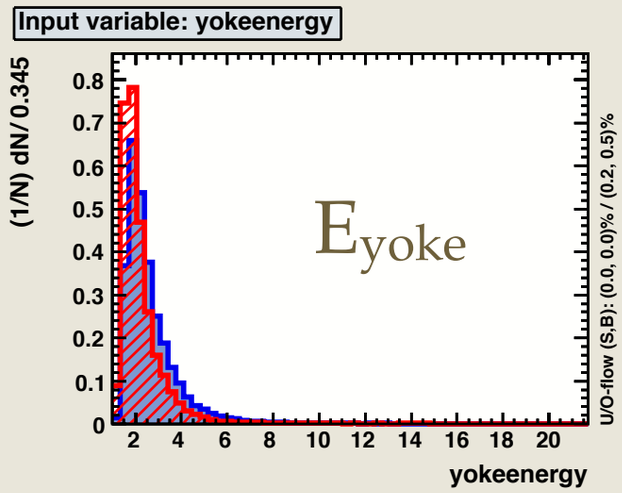


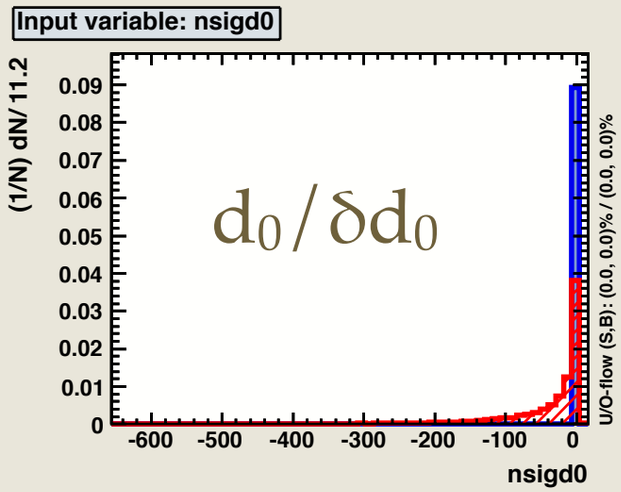



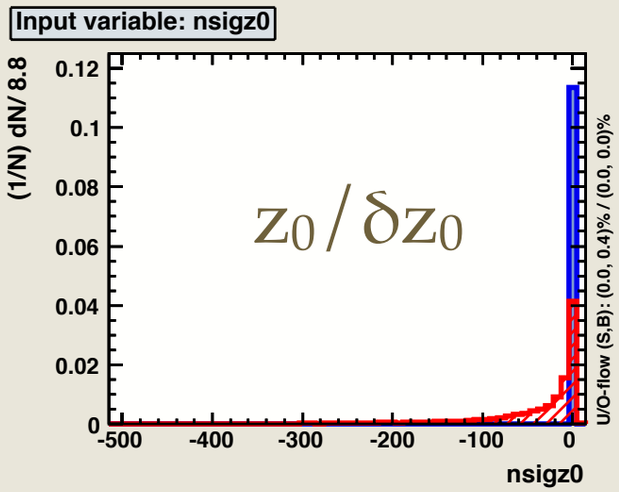



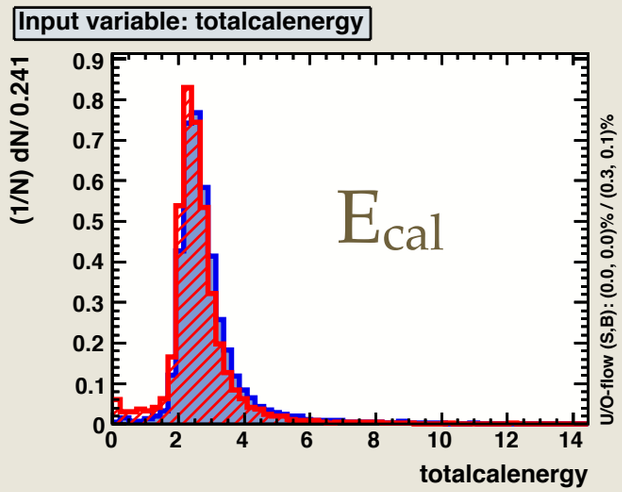



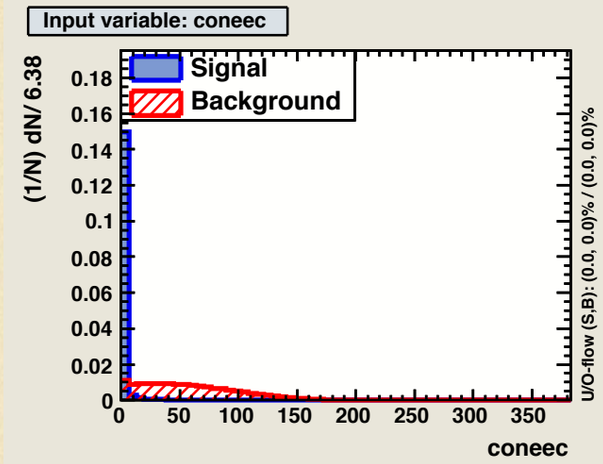



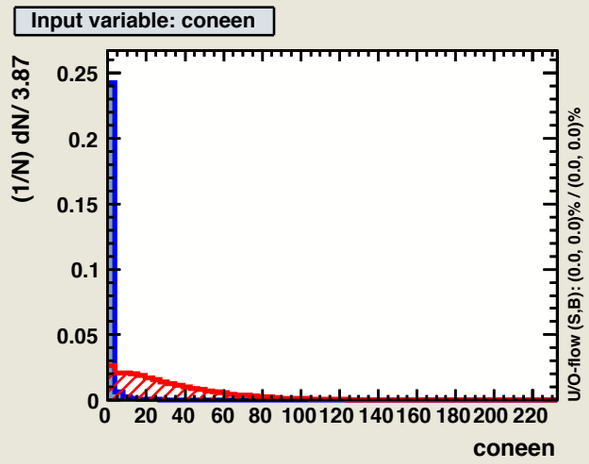



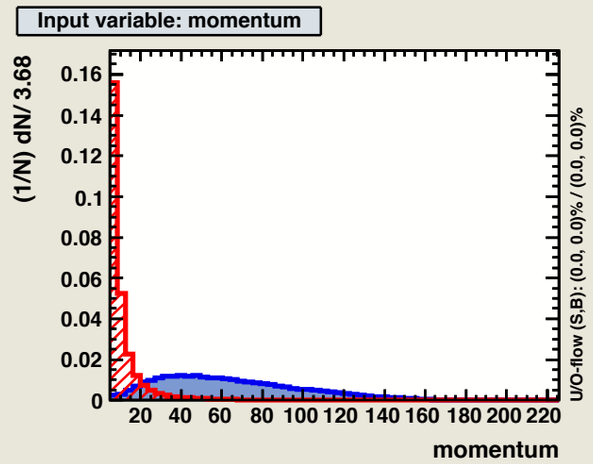



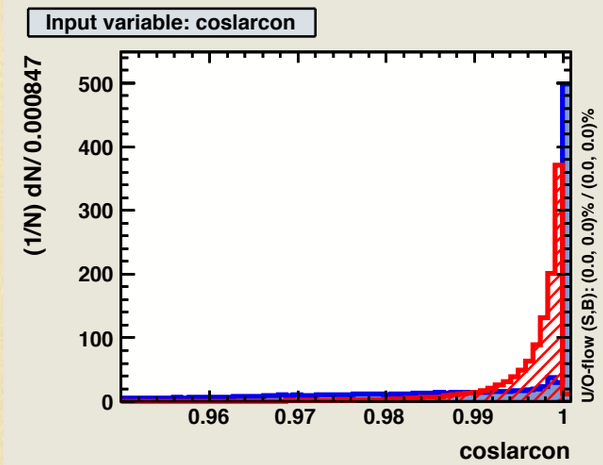



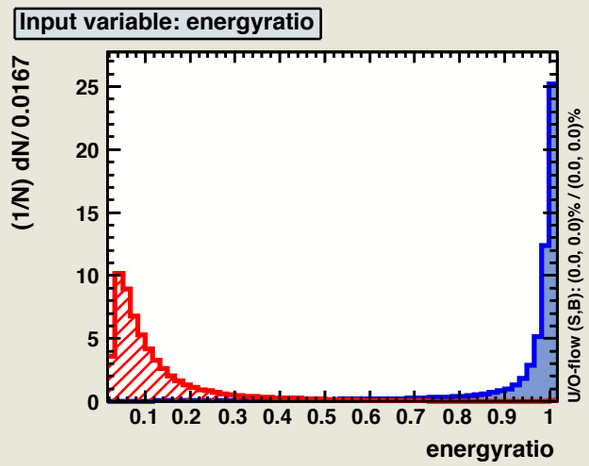
# input variables: electron

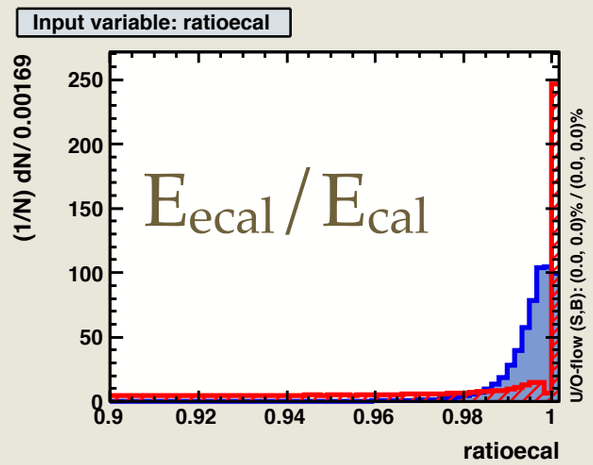


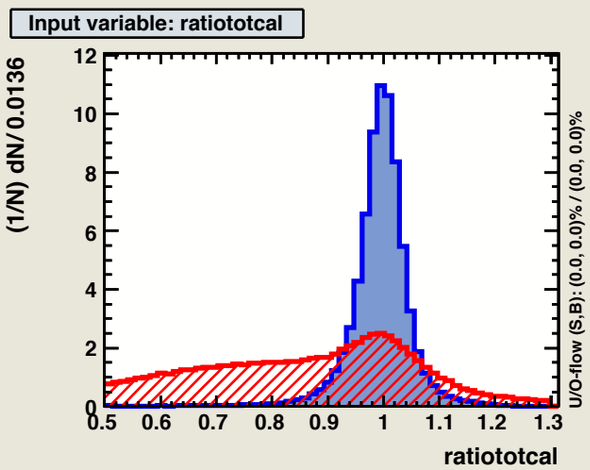



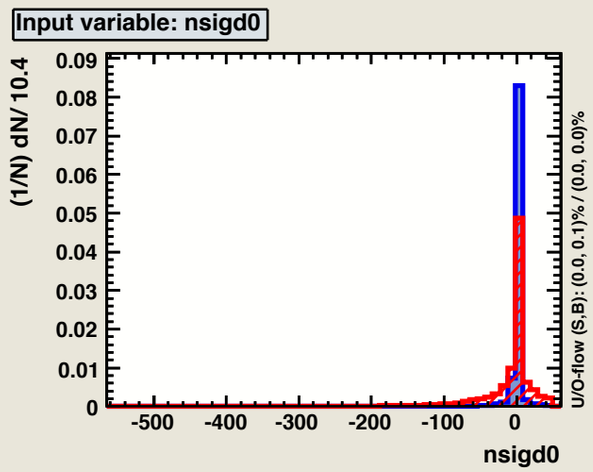



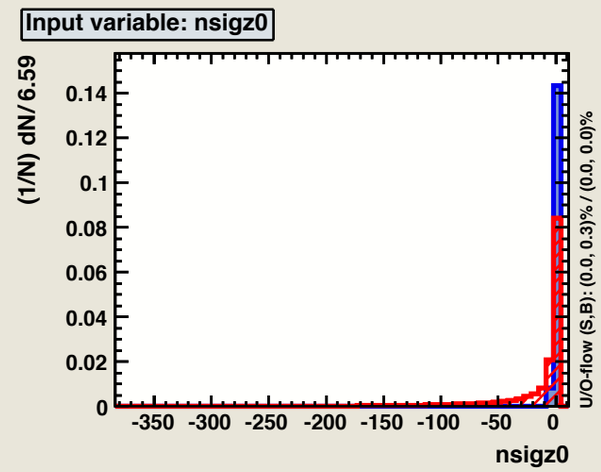



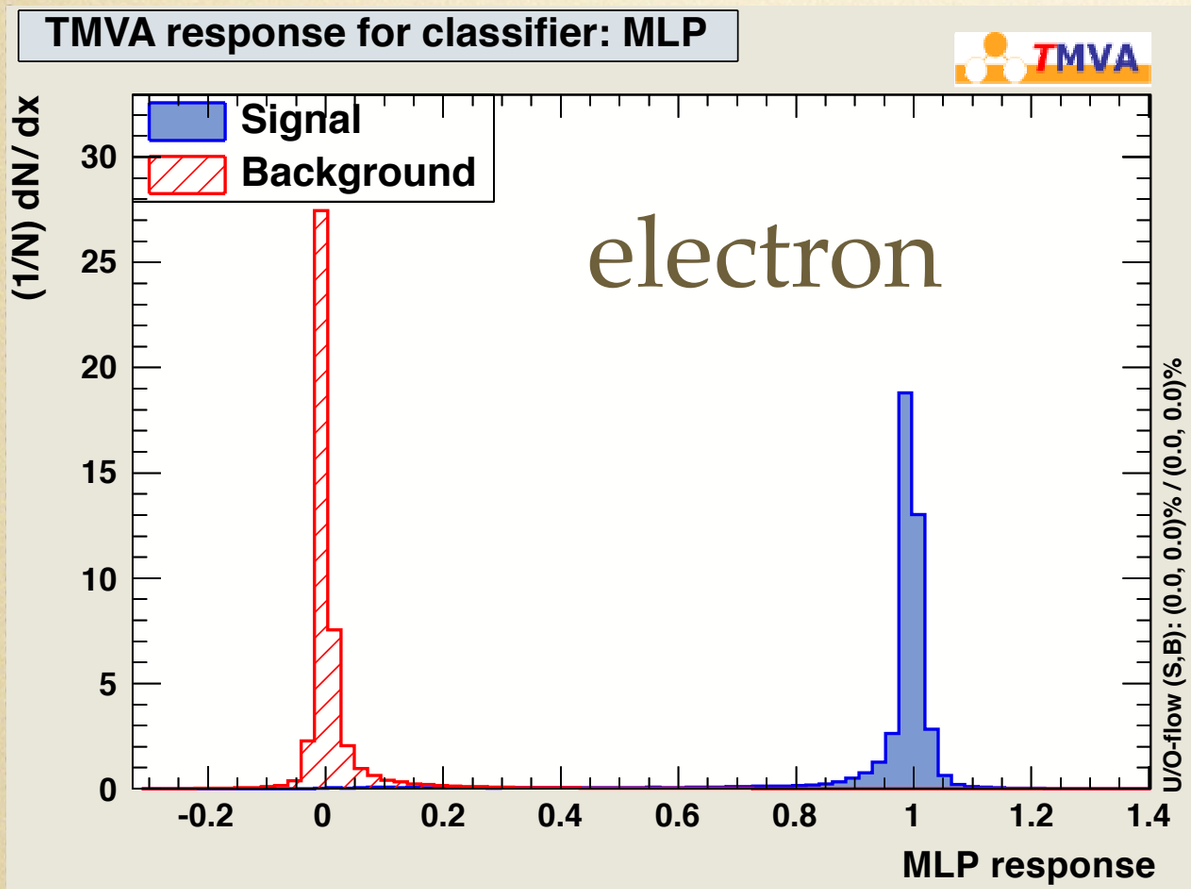



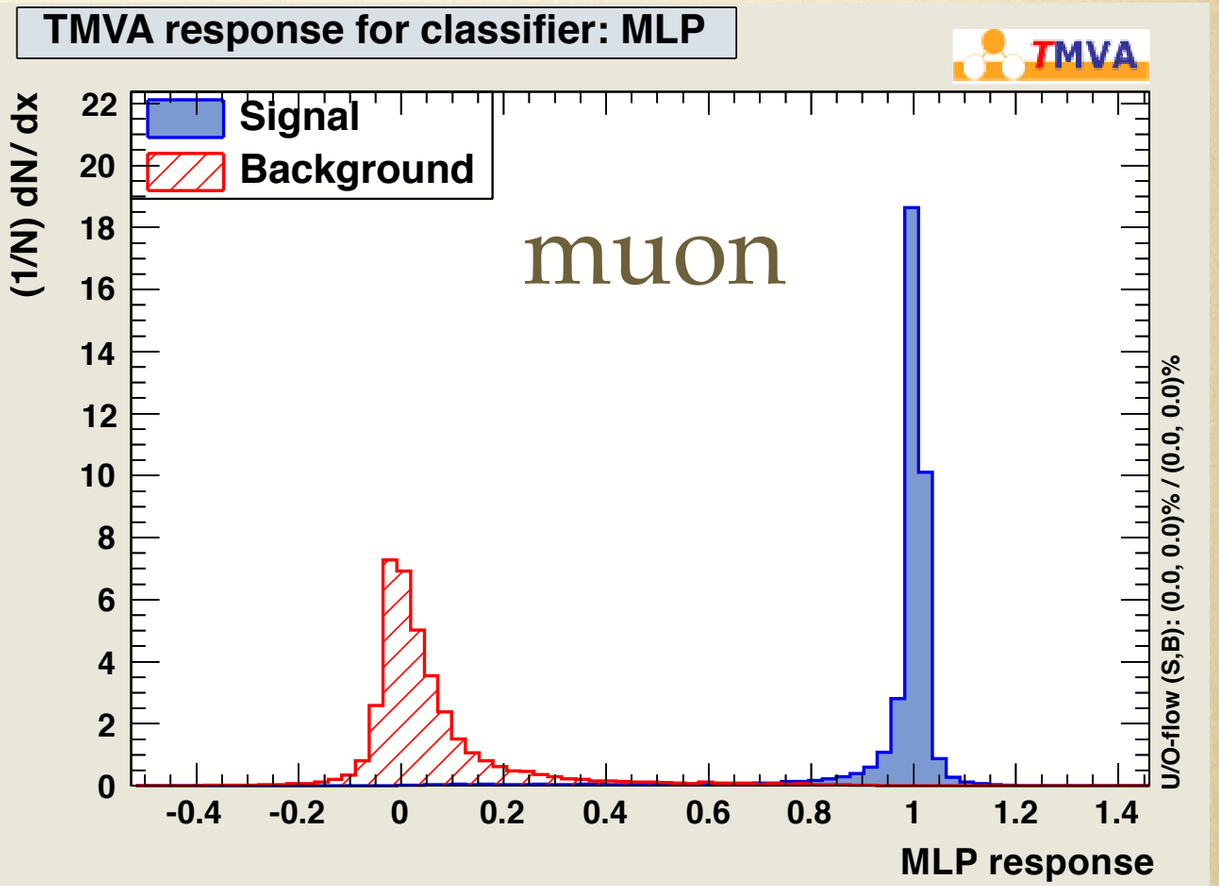



# neural-net output (tagging)




lepton tagging is associated to the selected lepton collection, cut can be optimised in final selection

# Available Processors in ilcsoft-v01-17-08

MarlinReco/Analysis/IsolatedLeptonTagging

(DBD ones: MarlinReco/Analysis/IsolatedLeptonFinder)
(private variants exist, e.g. in HHH by Masakazu, ttH by Yuji)

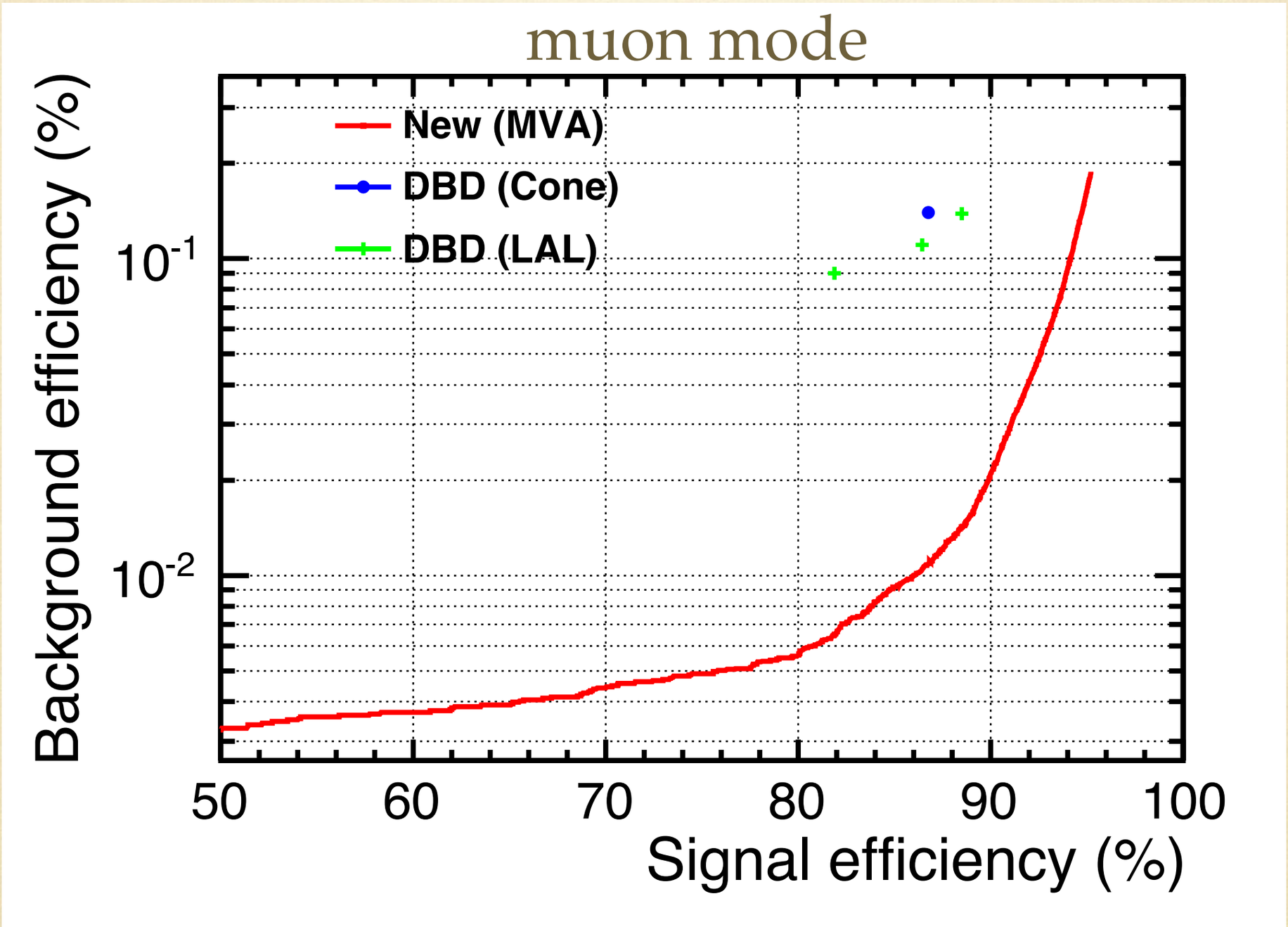
- see “README” for how to use it
- see “example” for steering file
  - several weights trained for different processes available
  - so far only one processor for single isolated leptons, will be added processor for pair of leptons (Z finder)

today’s update:

performance of this new tagging and comparison with DBD ones

# Signal (yyxylv) Eff. versus Background (yycyyc) Eff.

(thank Tino for the high statistics 6f samples)

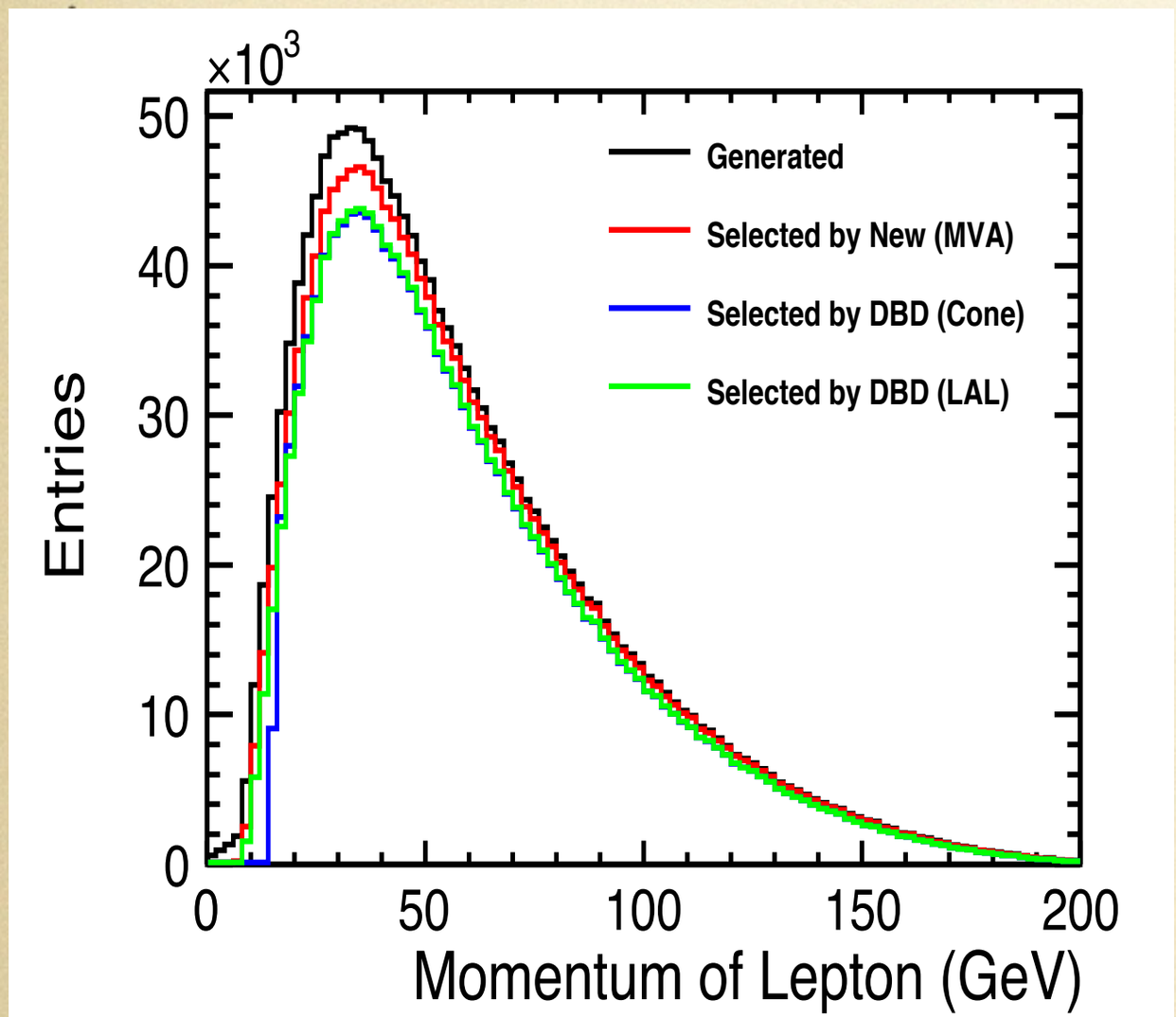


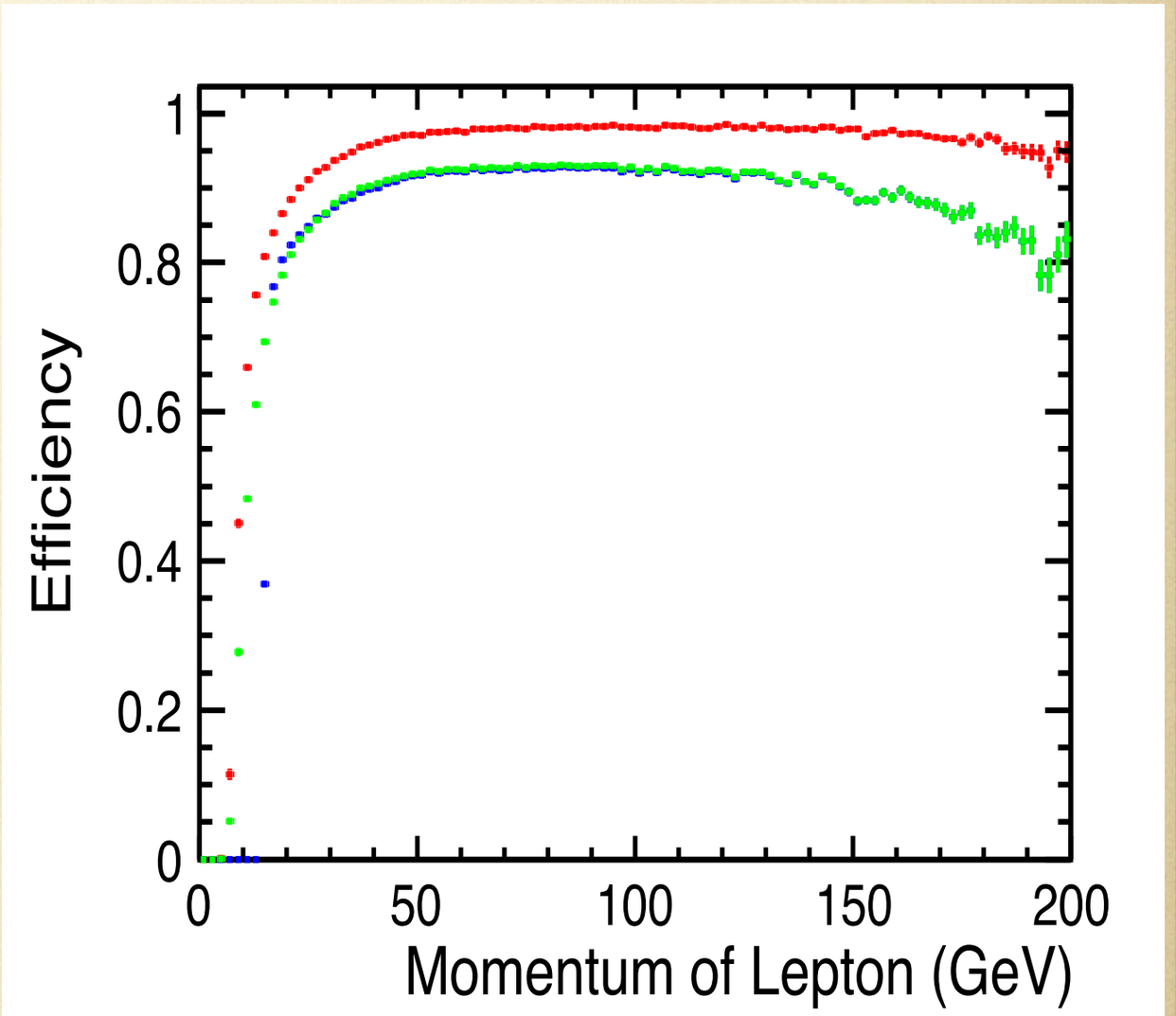

disclaimer: I used default setting for DBD ones, might be optimised;
for LAL algorithm, I tested using 4/5/6 jets as input

# signal efficiency versus momentum

(keep same background eff.)

muon mode



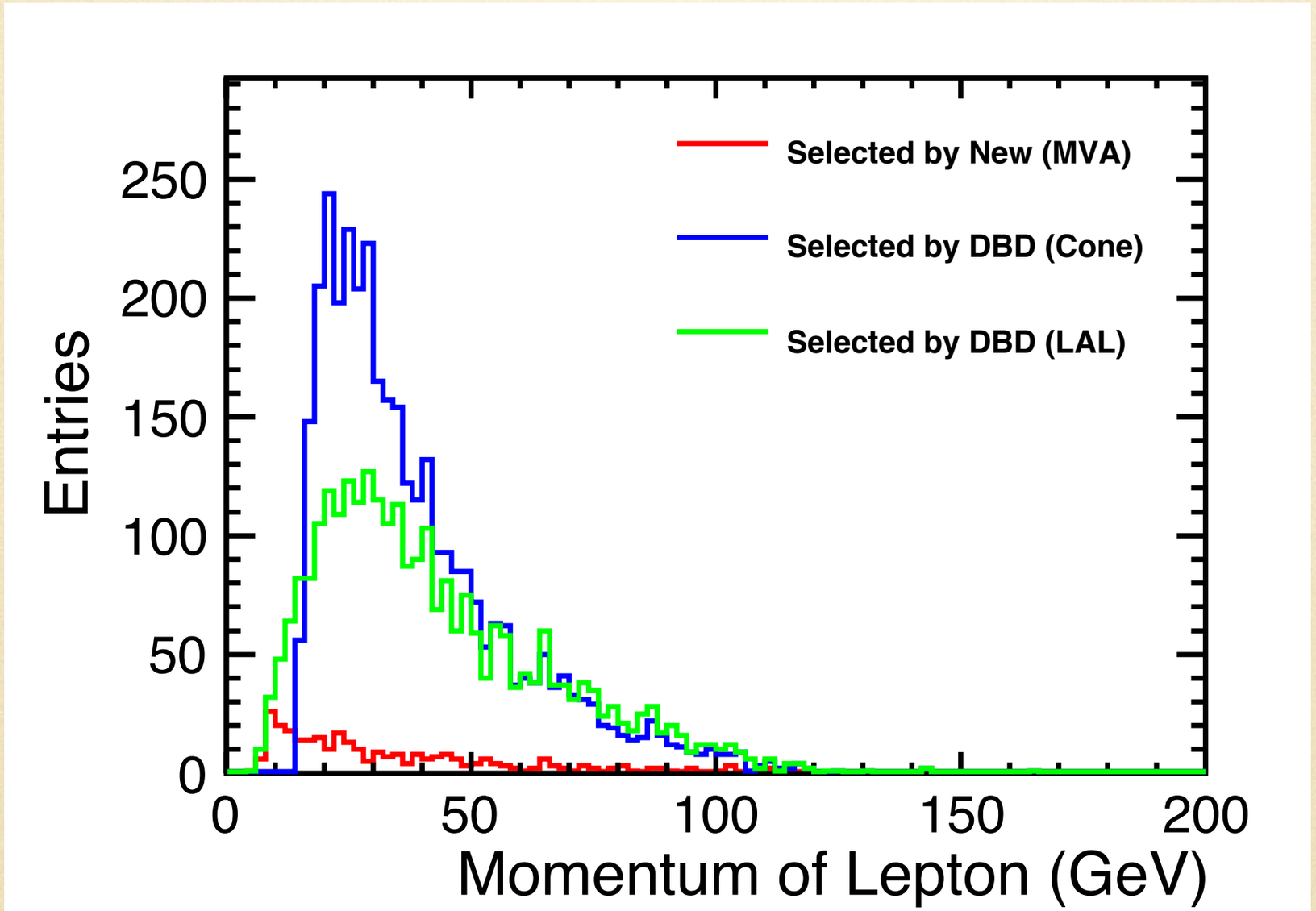




| Eff.(%) / Algorithm : | New(MVA) | DBD(Cone) | DBD(LAL) |
|---|---|---|---|
| Sig (yyxyμν) : | 94.65 | 86.75 | 88.51 |
| Bkg (yycyyc) : | 0.134 | 0.1396 | 0.1387 |

# in terms of background suppression

(keep same signal eff.)

muon mode

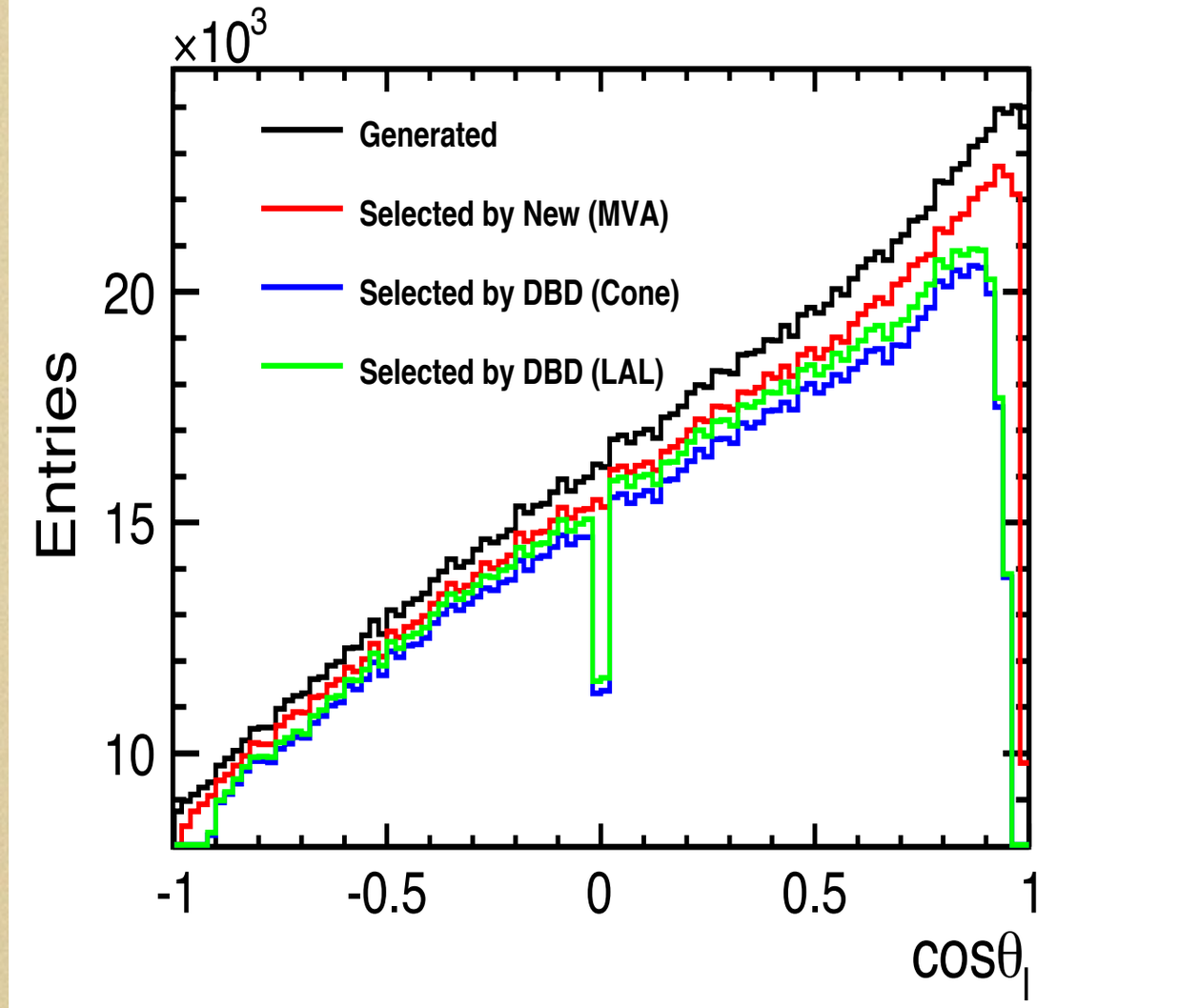


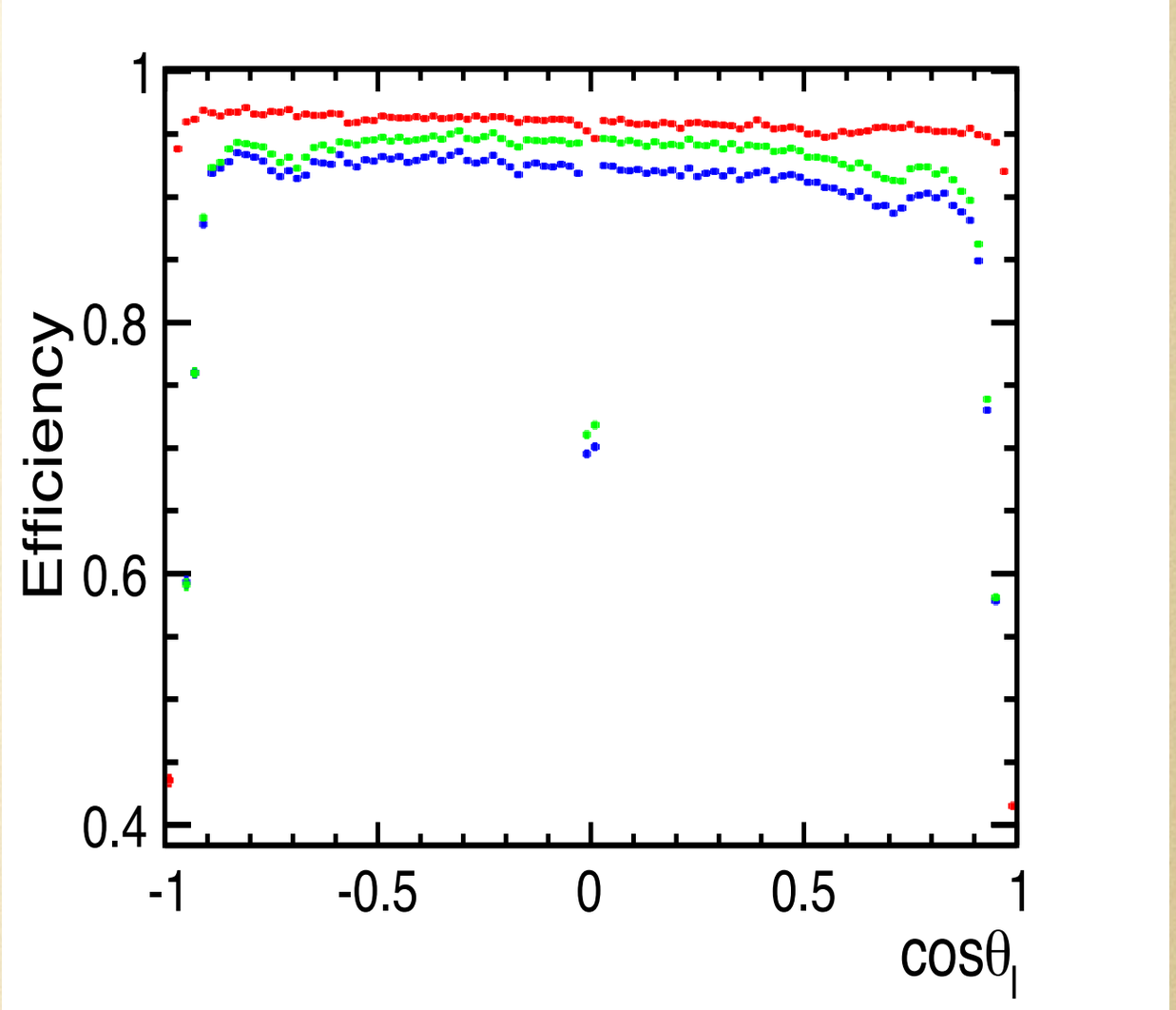

| Eff.(%) / Algorithm : | New(MVA) | DBD(Cone) | DBD(LAL) |
|---|---|---|---|
| Sig (yyxyμν) : | 87.26 | 86.75 | 86.44 |
| Bkg (yycyyc) : | 0.01172 | 0.1396 | 0.1104 |

# signal efficiency versus cosθ

(keep same background eff.)

muon mode




| Eff.(%) / Algorithm : | New(MVA) | DBD(Cone) | DBD(LAL) |
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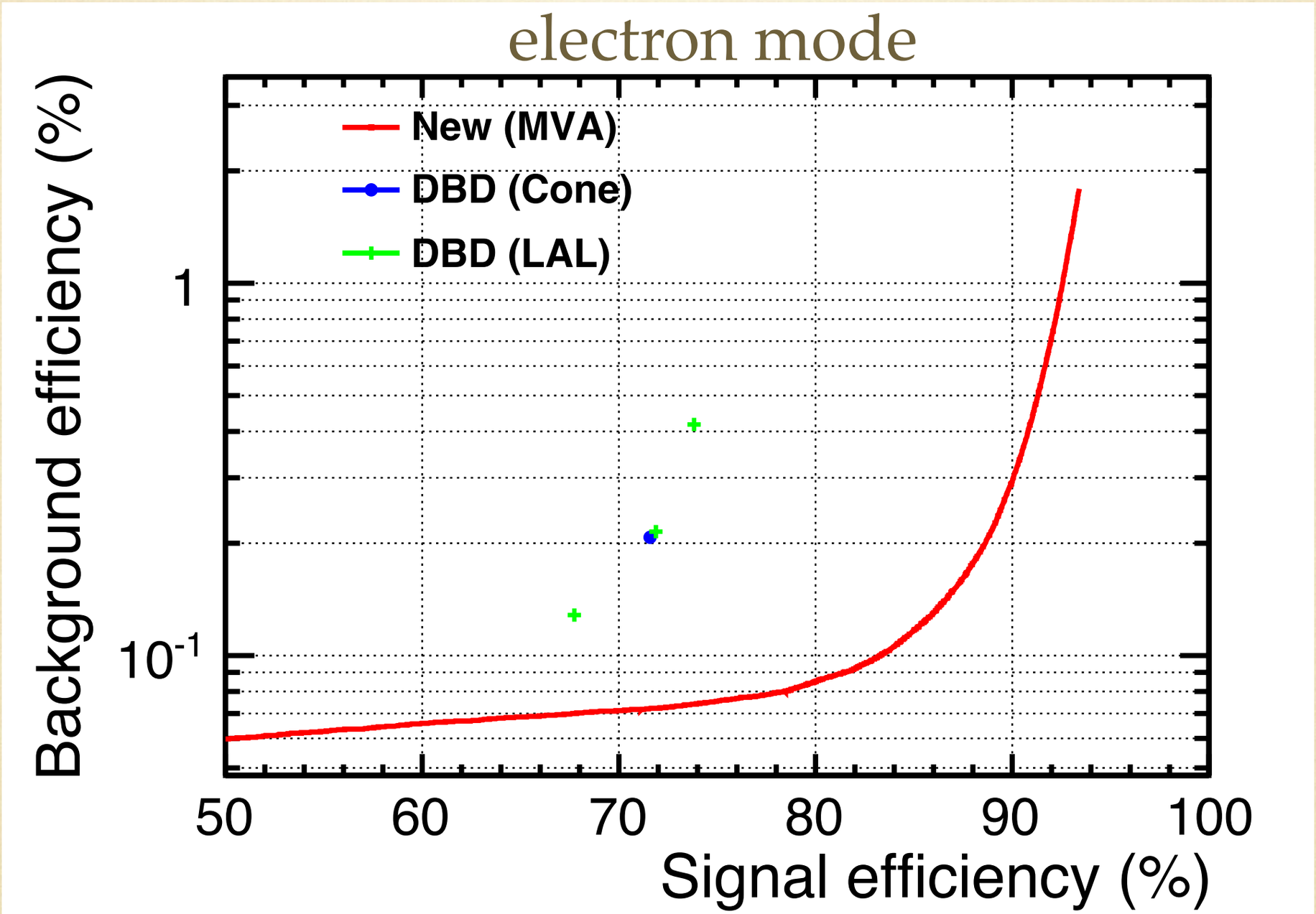
# Signal (yyxylv) Eff. versus Background (yycyyc) Eff.

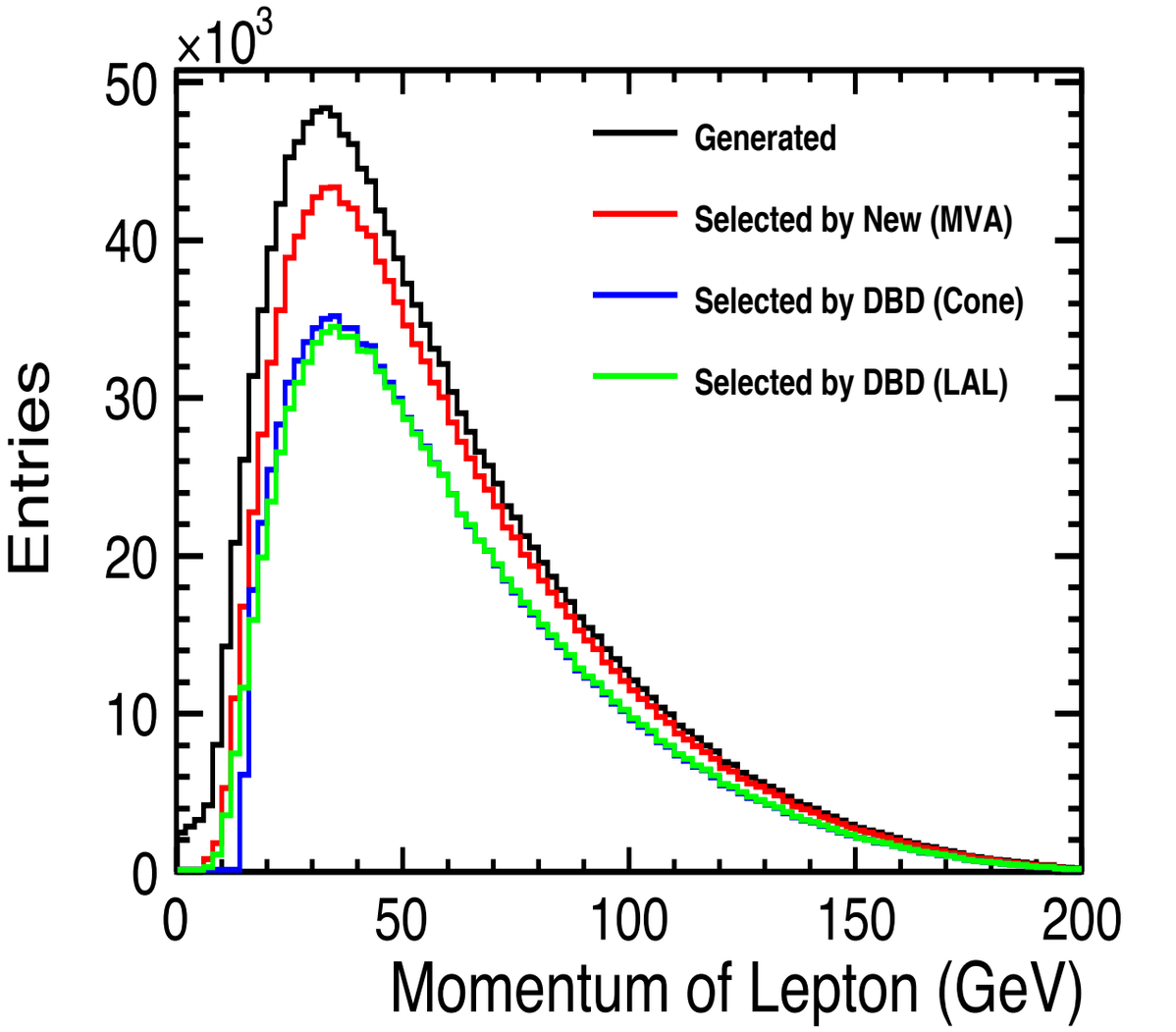


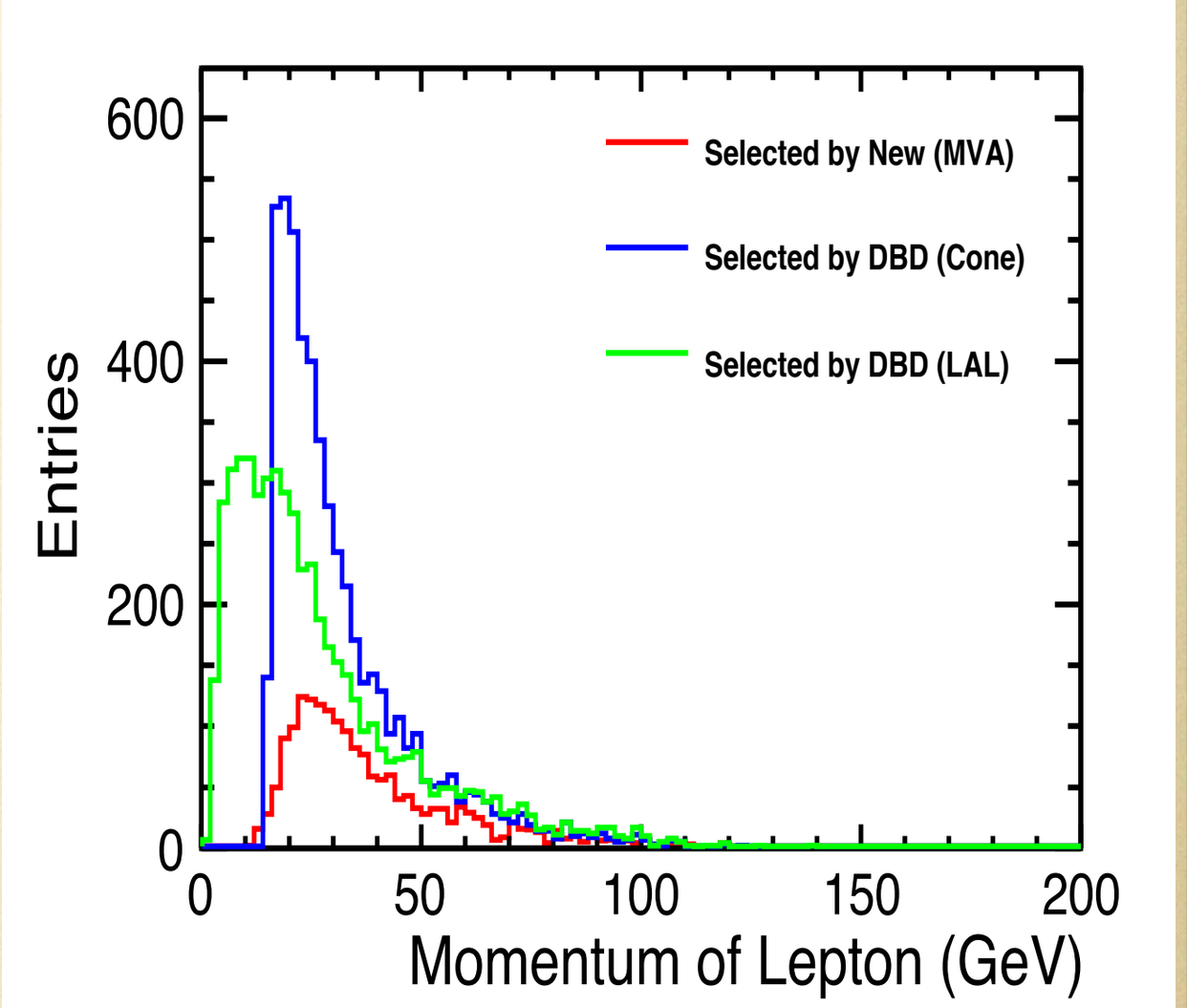

(it seems signal eff. of DBD ones are a bit too low, indicate significant tuning may be possible)

# sig/bkg efficiency versus momentum

(keep same bkg/sig eff.)

electron mode



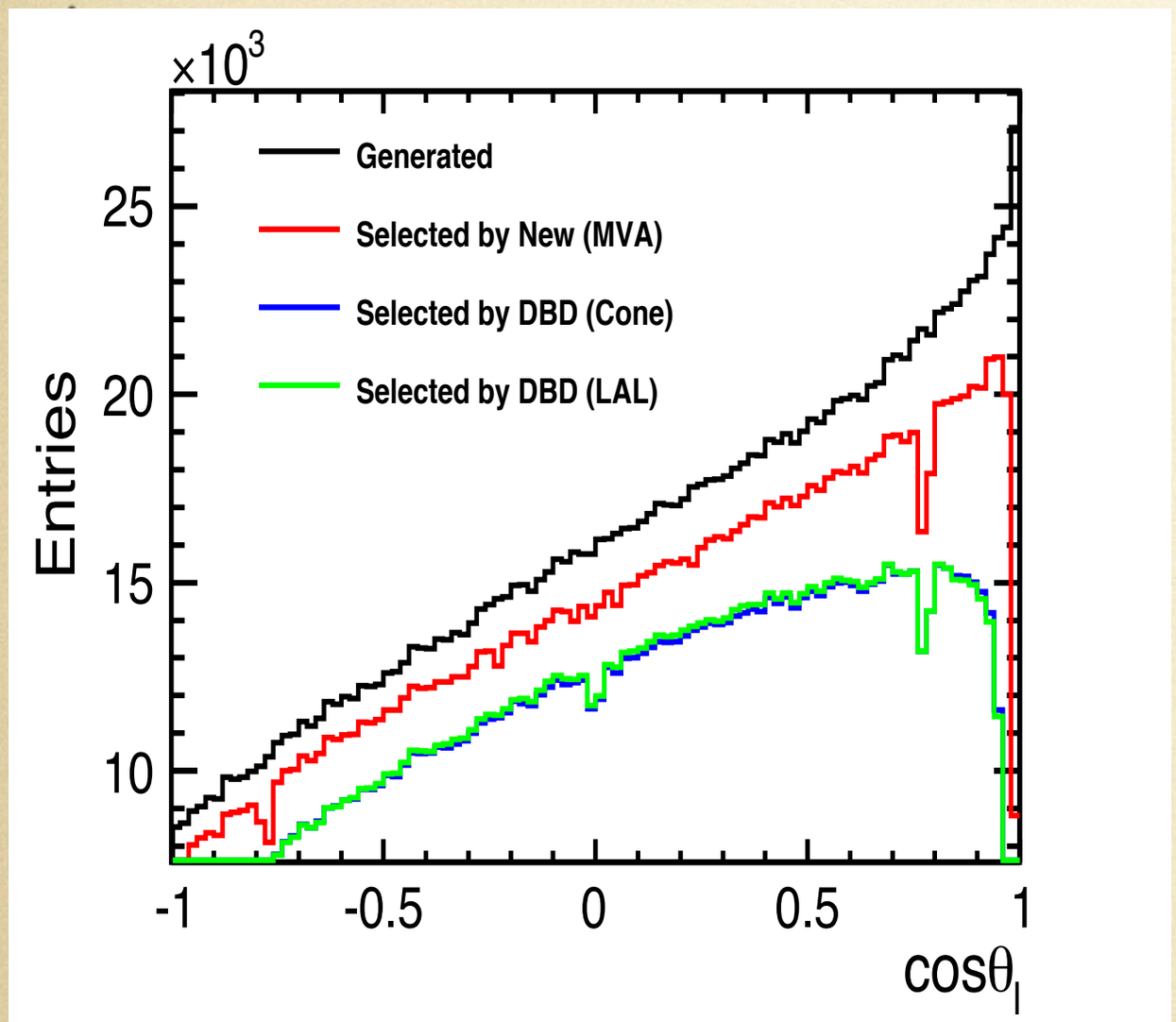

| Eff.(%) / Algorithm : | New(MVA) | DBD(Cone) | DBD(LAL) |
|---|---|---|---|
| Sig (yyxyev) : | 88.64 | 71.6 | 71.89 |
| Bkg (yycyyc) : | 0.2015 | 0.2079 | 0.2152 |

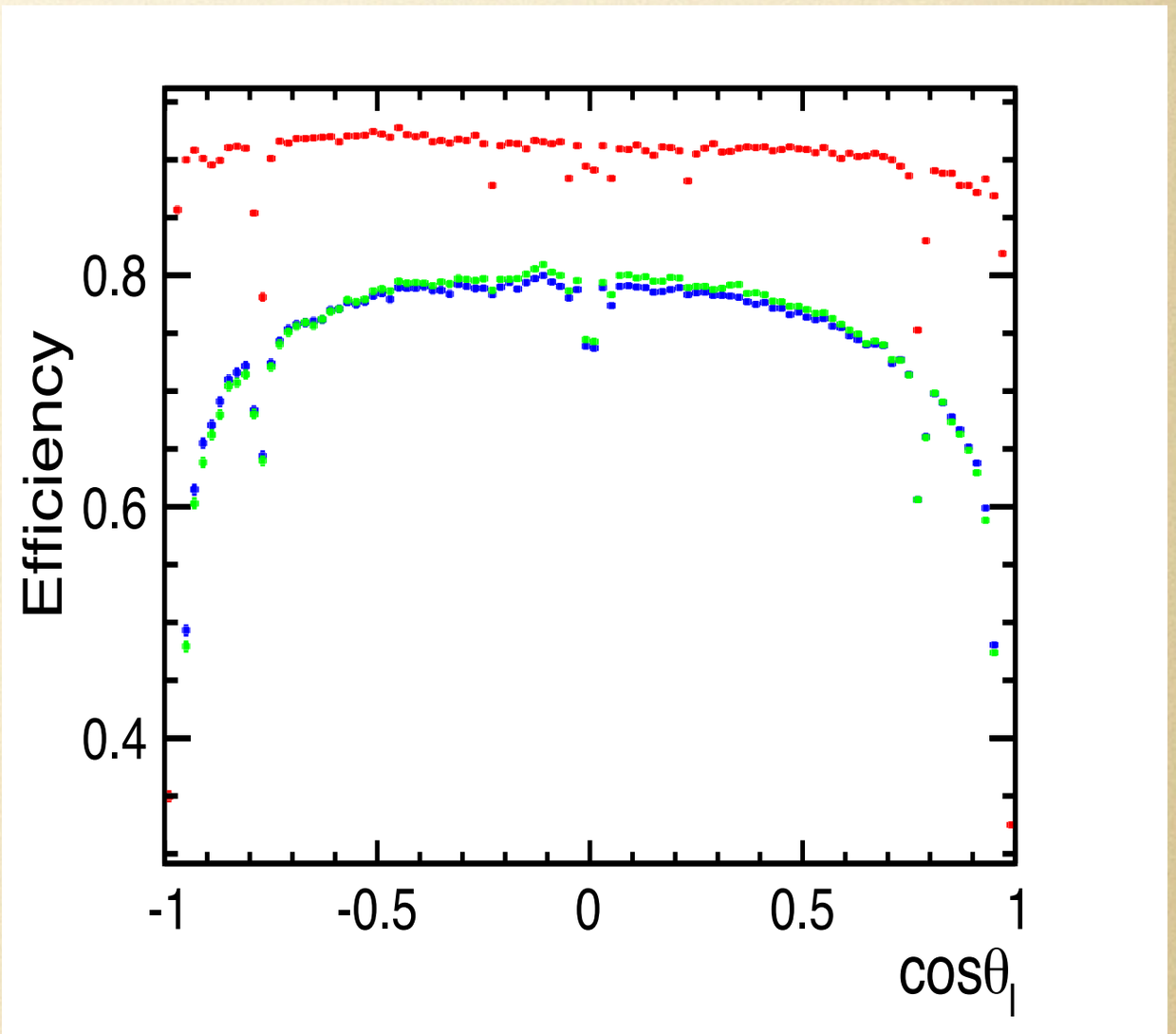
| New(MVA) | DBD(Cone) | DBD(LAL) |
|---|---|---|
| 72.17 | 71.6 | 71.89 |
| 0.07247 | 0.2079 | 0.2152 |

# sig/bkg efficiency versus cosθ

(keep same bkg / sig eff.)

electron mode

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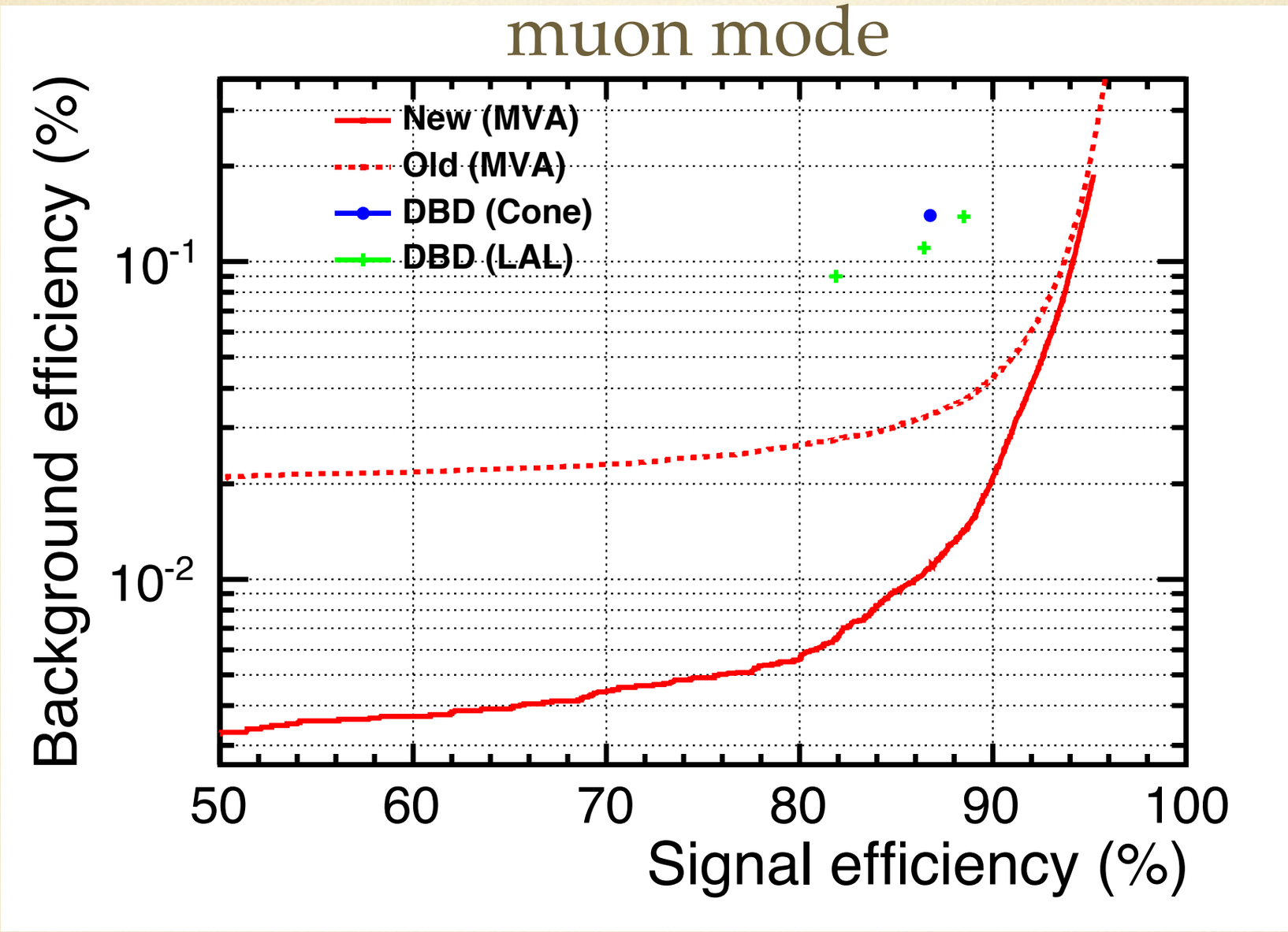
| New(MVA) | DBD(Cone) | DBD(LAL) |
|---|---|---|
| 72.17 | 71.6 | 71.89 |
| 0.07247 | 0.2079 | 0.2152 |

# impact of training

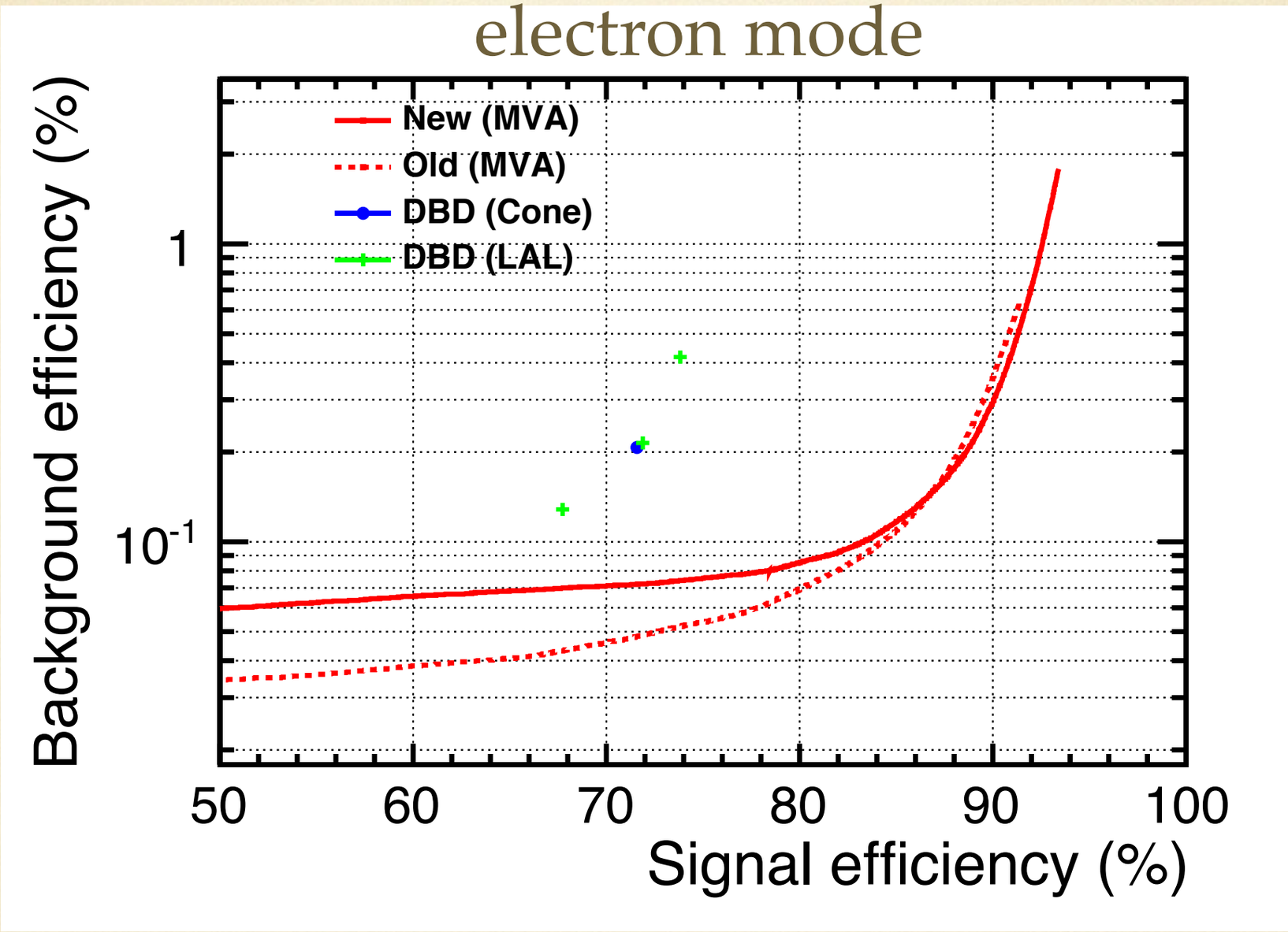
new training: yyxylv/yycyyc with overlay;
old training : yyxylv/bbbb no overlay




~a factor of 2 difference between trainings, in terms of bkg suppression
—> similar performance already confirmed in μμHH versus yyxyμν

# impact of training —> puzzle?

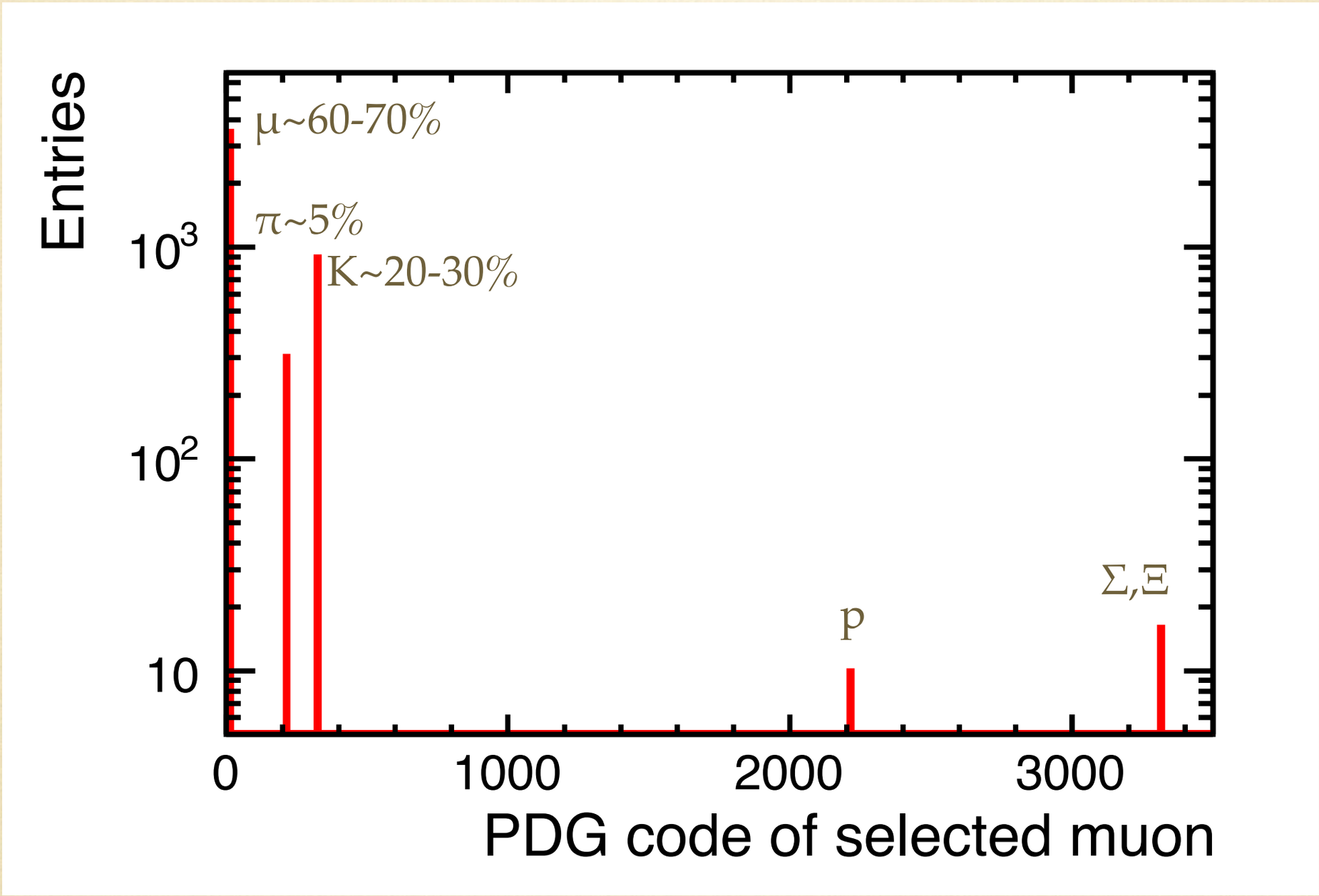
new training: yyxylv/yycyyc with overlay;
old training : yyxylv/bbbb no overlay




old training gives even better bkg suppression when sig eff is low, strange?

for next step: what kind of particles are still mis-tagged?

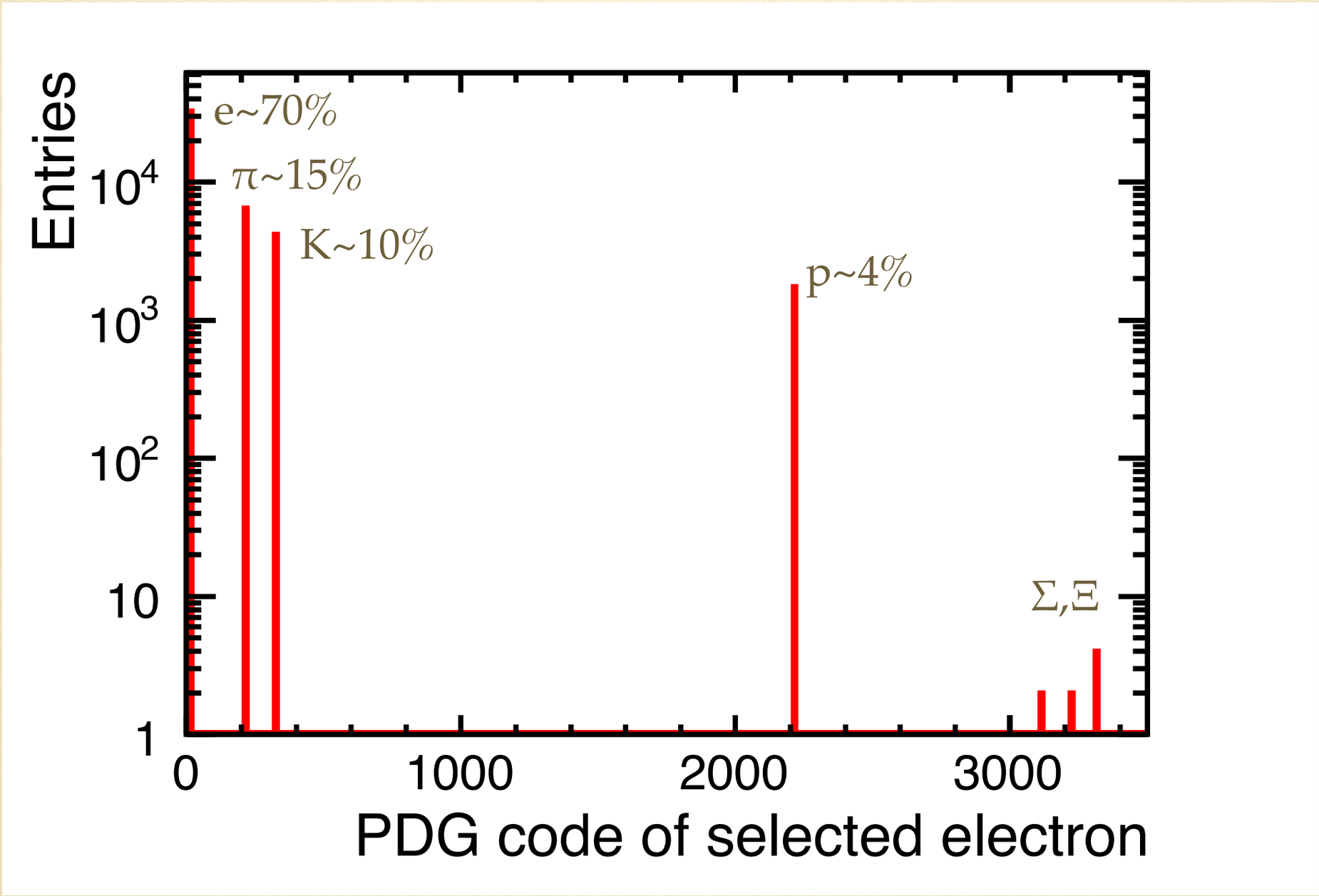
selected muon in yycyyc




K is tagged mostly because K->μν in Calorimeter

# for next step: what kind of particles are still mis-tagged?

## selected electron in yycyyc




dominated by charge π —> neutral π via charge exchange with nuclei in ECAL

# summary

- isolated lepton finder is one basic tool relevant for most of the analyses; worth our effort to make it common
- performance of existing three algorithms is evaluated and compared in a same basis; probably all of them are already very good in analyses where the lepton selection is not very crucial
- the new MVA based tagging shows better performance, and offers more degrees of freedom for optimisation of analysis, either with higher signal efficiency or higher background suppression
- remained mis-identification from K or $\pi$ in principle can be further improved by using matching of shower and track; dominant mis-identification $\mu/e$ from weak decay in jets shall be improved by more sophisticated isolation, e.g. utilise infinite layers of cones (dream)